Claims:

A regenerative fuel cell apparatus comprising an electrolyzer portion and a fuel cell portion;

wherein the electrolyzer portion has a cathode including a first electrolyzer cathode port and a second electrolyzer cathode port, an anode including a first electrolyzer anode port and a second electrolyzer anode port and a gas bypass conduit including a first gas bypass port and a second gas bypass port;

wherein the fuel cell portion comprises a fuel cell anode including a first fuel cell anode port and a second fuel cell anode port, a fuel cell cathode including a first fuel cell cathode port and a second fuel cell cathode port, and at least one coolant channel including a first coolant port and a second coolant port; and

wherein the regenerative fuel cell system includes at least one of:

(a) a connection between the second electrolyzer cathode port and the second fuel cell anode port, thereby to provide a continuous passage between the first electrolyzer cathode port and the first fuel cell anode port for hydrogen,

(b) a connection between the second electrolyzer anode port and the second coolant port, thereby to provide a continuous passage between the first electrolyzer anode port and the first coolant port; and

(c) a connection between the second gas bypass port and the second fuel cell cathode port, thereby to provide a continuous passage between the first gas bypass port and the first fuel cell cathode port.

2. A regenerative fuel cell apparatus as claimed in claim 1, which includes both a connection between the second electrolyzer cathode port and the second fuel cell anode port, and a connection between the second electrolyzer anode port and the second coolant port.

3. A regenerative fuel cell apparatus as claimed in claim 2, which additionally includes a connection between the second gas bypass port and the second fuel cell cathode port.

4. A regenerative fuel cell apparatus as claimed in claim 3, wherein the fuel cell portion and the electrolyzer portion are juxtaposed.

5. A regenerative fuel cell apparatus as claimed in claim 4, wherein the fuel cell portion and the electrolyzer portion are integral with one another, and wherein the fuel cell portion and the electrolyzer portion each include end plates, the end plates facing one another, wherein an end plate of the fuel cell portion adjacent an end plate of the electrolyzer portion includes said second ports.

6. A regenerative fuel cell apparatus as claimed in claim 5, which includes an insulator between said pair of adjacent end plates.

7. A regenerative fuel cell apparatus as claimed in claim 5, wherein the end plates of the fuel cell portion and the electrolyzer portion are integral and are provided as a common separator plate, including said second ports.

8. A regenerative fuel cell apparatus as claimed in claim 6 or 7, wherein the electrolyzer portion comprises a plurality of individual cells each including a membrane exchange assembly, an anode bipolar plate and a cathode bipolar plate, wherein the electrolyzer anode comprises said anode bipolar plates and the electrolyzer cathode comprises said cathode bipolar plates, and wherein the gas bypass conduit of the electrolyzer comprises a

plurality of bypass conduits, each extending between an adjacent pair of electrolyzer cells.

9. A regenerative fuel cell apparatus as claimed in claim 8, wherein the fuel cell portion comprises a plurality of individual fuel cells, each comprising a membrane exchange assembly, an anode bipolar plate and a cathode bipolar plate, wherein the fuel cell anode comprises said anode bipolar plates of the fuel cells and the fuel cell cathode comprises said cathode bipolar plates of the fuel cells, and wherein said at least one coolant channel comprises a plurality of coolant channels provided between adjacent pairs of fuel cells.

10. A regenerative fuel cell apparatus as claimed in claim 9, wherein the electrolyzer portion is provided above the fuel cell portion.

11. A regenerative fuel cell apparatus as claimed in claim 9, wherein the fuel cell portion includes a third fuel cell anode port, and a conduit providing a direct passage between the second and third fuel cell anode ports, whereby, in use, in a fuel cell mode of operation, hydrogen gas passes between the first and second fuel cell anode ports and across the individual fuel cell anode bipolar plates, and in an electrolyzer mode of operation, the generated hydrogen can pass between the first and third fuel cell anode ports.

12. A regenerative fuel cell apparatus as claimed in claim 4 or 5, wherein the first electrolyzer cathode port is closable, whereby in the electrolyzer mode of operation, hydrogen is withdrawn through the fuel cell portion.

13. A regenerative fuel cell apparatus as claimed in claim 11, wherein the first electrolyzer cathode port is closable, whereby in the electrolyzer mode of operation, hydrogen is withdrawn through the fuel cell portion.

14. A regenerative fuel cell apparatus as claimed in claim 4 or 5, wherein the first electrolyzer cathode port is adapted to withdraw hydrogen from the electrolyzer in the electrolyzer mode, and wherein means are provided for purging water from the cathode of the electrolyzer in the electrolyzer mode.

15. A regenerative fuel cell apparatus as claimed in claim 14, wherein said means for purging water comprises a purge valve connected to the second electrolyzer cathode port, whereby, in use, with the first electrolyzer cathode port oriented above the second electrolyzer cathode port, hydrogen is withdrawn from the first electrolyzer cathode port and water is purged from the electrolyzer cathode through said purge valve.

16. A regenerative fuel cell apparatus as claimed in claim 12, which includes a valve provided between the second electrolyzer cathode port and the second fuel cell anode port and wherein a discharge line for hydrogen is provided connected to the valve, whereby, in use, the valve connects the second electrolyzer cathode port to the second fuel cell anode port for supply of hydrogen to the fuel cell portion in the fuel cell mode, and, in an electrolyzer mode of operation, the valve connects the second electrolyzer cathode port to the discharge line, for discharging generated hydrogen and any entrained water.

17. A regenerative fuel cell apparatus comprising an electrolyzer portion and a fuel cell portion, wherein the electrolyzer portion and the fuel cell portion are integral with one another.

18. A regenerative fuel cell apparatus as claimed in claim 17, wherein the electrolyzer portion and the fuel cell portion have similar cross-sections and include common clamping elements securing the regenerative fuel cell apparatus together.

19. A regenerative fuel cell apparatus as claimed in claim 18, wherein the electrolyzer portion comprises a plurality of individual cells each

including a membrane exchange assembly, an anode bipolar plate and a cathode bipolar plate, wherein the anode bipolar plates form an electrolyzer anode, the cathode bipolar plates form an electrolyzer cathode, and wherein a plurality of gas by-pass conduits are provided extending between the individual cells.

20. A regenerative fuel cell apparatus as claimed in claim 19, wherein the fuel cell portion comprises a plurality of individual cells, each comprising a membrane exchange assembly, an anode bipolar plate and a cathode bipolar plate, wherein the anode bipolar plates provide the fuel cell anode, the cathode bipolar plates provide the fuel cell cathode and wherein a plurality of coolant channels are provided extending between adjacent pairs of fuel cells.

21. A regenerative fuel cell apparatus as claimed in claim 20, wherein the electrolyzer portion includes: a first electrolyzer cathode port for hydrogen, a second electrolyzer cathode port, a first electrolyzer anode port for water and, in the electrolyzer mode, water, a second electrolyzer anode port, a first gas by-pass port for an oxidant and a second gas by-pass port;

wherein the fuel cell portion includes a first fuel cell anode port for hydrogen and a second anode fuel cell port connected to the second electrolyzer cathode port, a first fuel cell cathode port for an oxidant and a second fuel cell cathode port connected to the second gas by-pass port, a first coolant port and a second coolant port connected to the second electrolyzer anode port, for passage of water as a coolant.

22. A method of operating a regenerative fuel cell apparatus including an electrolyzer portion and a fuel cell portion, the method comprising at least one of:

(a) in a fuel cell mode of operation, supplying hydrogen and an oxidant to the fuel cell to generate electricity, withdrawing water from the fuel cell and passing a coolant through the fuel cell, wherein the method includes

passing at least one of the fuel gas, the oxidant and the water through the electrolyzer portion; and

(b) in an electrolyzer mode of operation, supplying water to the electrolyzer and electric current to electrolyzer water to generate oxygen and hydrogen and withdrawing oxygen, hydrogen and residual water from the electrolyzer, wherein the method includes passing at least one of the water, oxygen and hydrogen through the fuel cell portion.

23. A method as claimed in claim 22, which includes, in the fuel cell mode, passing water through the anode of the electrolyzer portion, to maintain the electrolyzer portion heated.

24. A method as claimed in claim 23, which includes passing hydrogen for the fuel cell through the electrolyzer cathode, providing at least one gas by-pass conduit in the electrolyzer portion and passing oxidant for the fuel cell through said at least one gas by-pass conduit, whereby the oxidant and the hydrogen are preheated in the electrolyzer portion.

25. A method as claimed in claim 23, which includes, in the electrolyzer mode of operation, passing water through a coolant channel of the fuel cell portion and into the anode of the electrolyzer, withdrawing oxidant and residual water from the anode of the electrolyzer, and withdrawing hydrogen from the cathode of the electrolyzer.

26. A method as claimed in claim 25, which includes withdrawing hydrogen from the cathode of the electrolyzer through the anode of the fuel cell portion.

27. A method as claimed in claim 26, which includes withdrawing hydrogen through a conduit by-passing active areas of the fuel cell portion.

28. A method as claimed in claim 27, which includes, in the electrolyzer mode of operation, withdrawing hydrogen and entrained water from a port located between the electrolyzer and fuel cell portions, and subsequently separating hydrogen from the water for storage.